

HIGH-PERFORMANCE MODULAR CLASSROOMS

Can We Improve Modular Classrooms?

California schools use about 100,000 relocatable classrooms (RCs, often referred to as “portable” or “modular” classrooms). Many have poor indoor air quality and use more energy than they should. Problems include:

- poor ventilation
- noisy systems
- high levels of organic compounds in the air.

Can the indoor environmental quality and energy efficiency of RCs be improved? Research shows that the answer is yes.

PIER researchers developed a prototype relocatable classroom using energy-efficient heating, ventilation, and air-conditioning technologies, and low emissions interior materials, and tested them at two California schools with different climates.

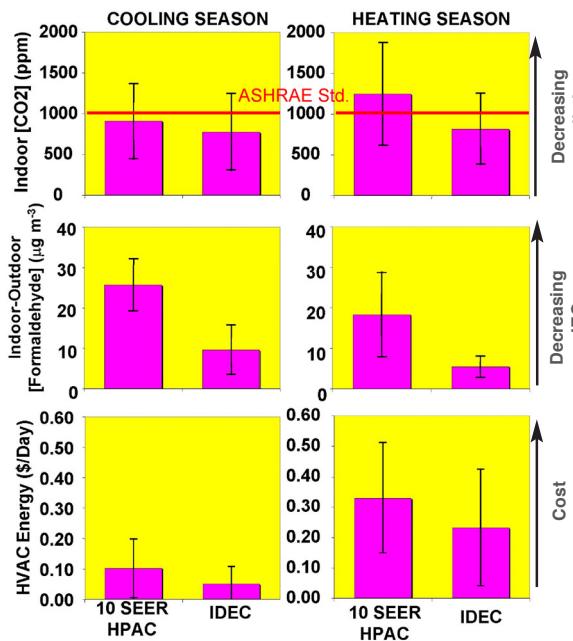
The study measured the parameters shown in the table below.

IEQ and Energy Use Monitoring

Air Quality	Energy Monitoring
Carbon dioxide (I,O)	Temperature (I,O)
Particle number & size (I,O)	Relative humidity (I,O)
Selected VOCs and aldehydes (I,O)	Energy consumption (lights, HVAC, total)
Thermal comfort (I)	Meteorology (O)
Noise level (I)	Door & window operation

I = Indoors, O = Outdoors

These graphs show how the indoor air quality improves with lower heating and cooling costs in advanced relocatable classrooms. The values on the left side of the graphs are for a conventional 10 SEER (seasonal energy efficiency ratio) HVAC system, while those on the right are for new direct/indirect evaporative cooling systems with hydronic heating.



Each classroom was equipped with a conventional HVAC system and a new indirect/direct evaporative cooling (IDEC) system with hydronic heating. Unlike the standard HVAC system, the IDEC provides continuous fresh air ventilation, regardless of heat or cooling demand. The classrooms were operated alternately each week with the standard and prototype HVAC systems. VOC concentrations in the classrooms during school hours were monitored to compare the VOC levels in the source-modified and conventional RCs.

What Did We Learn?

It is possible to simultaneously improve indoor air quality and lower energy use in carefully designed buildings.

Compared to conventional HVAC, the IDEC with gas-fired hydronic heat provided:

- similar thermal conditioning and comfort levels.
- significantly reduced indoor carbon dioxide concentrations.
- reductions of 25 to 75% in indoor-generated pollutants including formaldehyde.
- up to 50% savings in HVAC costs.

Who Benefits from Our Research?

- Students and teachers
 - improved environmental quality
 - more fresh air
 - reduced levels of irritating and toxic indoor pollutants.
- School districts
 - learn the potential for implementing improvements in classroom environments while reducing energy costs.

If 4,000 new RCs used advanced hybrid HVAC, each year California schools would:

- save 2.8 TBtu energy
- reduce winter peak use by 24 MW
- reduce summer peak use by 13 MW
- in 10 years save \$48.5 million in cumulative operating costs.

INTERESTED?

Technical reports are available on the High Performance Commercial Buildings System website:

<http://buildings.lbl.gov/hpcbs/Pubs.html>

For more information on Indirect/Direct Evaporative Cooling visit the Davis Energy Group website:

<http://www.davisenergy.com>

More information on IEQ in schools is at:

<http://www.dhs.ca.gov/iaq>

LBNL has an entire department devoted to research on Indoor Environmental Quality:

<http://eetd.lbl.gov/IE.html>



This project is part of LBNL's High-Performance Commercial Building Systems program, a three-year public-private research initiative targeting substantial reductions in the energy costs of commercial buildings.

For access to all program results, see:
<http://buildings.lbl.gov/hpcbs>

High-Performance Modular Classrooms



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Contact information:

California Energy Commission
<http://www.energy.ca.gov/pier/index.htm/>

Martha Brook
mbrook@energy.state.ca.us

Michael Apte, Project Lead
Indoor Environment Department
LBNL
mgapte@lbl.gov

Stephen Selkowitz, Program Coordinator
LBNL
seselkowitz@lbl.gov



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ENERGY EFFICIENCY
AND INDOOR
ENVIRONMENTAL
QUALITY IN
RELOCATABLE
CLASSROOMS

